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# Herring Spawning Stock Biomass Estimates from Diving Surveys for the Central Coast in 1986

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# HERRING SPAWNING STOCK BIOMASS ESTIMATES FROM DIVING SURVEYS FOR THE CENTRAL COAST IN 1986

by

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## ABSTRACT

Schweigert, J. F. and Haegele, C. W. 1988. Herring spawning stock biomass estimates from diving surveys for the Central Coast in 1986. Can. MS Rep. Fish. Aquat. Sci. 1984: 43 p.

Diving and surface spawn surveys in 1986 indicated that 25,946 tonnes of herring spawned in the Central Coast District (Statistical Areas 6-9). In addition, roe seine fisheries in Area 7 caught 1707 tonnes and the roe gillnet fisheries in Areas 6 and 7 caught 1084 tonnes of herring. The food and bait fisheries in Area 8 caught another 30 tonnes of fish.

Most of the spawning occurred in Area 7. Over half (57%) of the spawn occurred in this area, where 72 km of spawn was deposited by 14,703 tonnes of herring. In Area 6 38.7 km of spawn was deposited by 7168 tonnes (28%) of fish. Area 8 spawn deposition totalled 15.7 km and 2844 tonnes (11%). Finally, the spawn at the head of Rivers Inlet (Area 9) totalled 16.3 km and 1231 tonnes of herring or 5 % of the total Central coast deposition.

The 1986 diving survey was the first conducted in the Central Coast and results indicated that spawn distribution was similar to that in other Districts. Spawn was confined primarily to the intertidal and upper subtidal zone (above 3 m below chart datum). The percent cover of vegetation and the sample weights were also similar to those in other Districts and declined with depth only in the lower subtidal zone (deeper than 3 m below chart datum). Egg layers and egg density followed a similar pattern. However, the slopes of the beaches were much steeper than for other spawn surveyed to date. In addition, the vegetation types utilized for spawning differed from other Disticts, consisting primarily of kelps, rockweeds and filamentous red algae.

## RÉSUMÉ

Schweigert, J. F. and Haegele, C. W. 1988. Herring spawning stock biomass estimates from diving surveys for the Central Coast in 1986. Can. MS Rep. Fish. Aquat. Sci. 1984: 43 p.

D'après les relevés sur la fraye effectués par plongée et en surface en 1986, 25 946 tonnes de harengs ont pondu dans le district de la zone centrale de la côte (zones statistiques 6-9). De plus, les prises de hareng rogué à la senne dans la zone 7 se sont élevées à 1 707 tonnes et les prises de hareng rogué aux filets maillants dans les zones 6 et 7, à 1 084 tonnes. Dans la zone 8, on a capturé trente autres tonnes de poissons destinés à la consommation et aux appâts.

La fraye a lieu presque entièrement dans la zone 7. Plus de la moitié des oeufs (57 %) sont déposés dans cette zone: 14 703 tonnes de harengs ont pondu sur une longueur de 72 km. Dans la zone 6, 7 168 tonnes (28 %) de poissons ont déposé des oeufs sur une longueur de 38,7 km. Dans la zone 8, 2 844 tonnes (11 %) de poissons ont pondu sur une longueur de 15,7 km. Finalement, le nombre d'oeufs déposés à l'amont de l'inlet Rivers (zone 9) couvrait une longueur de 16,3 km (1 231 tonnes de harengs) ou 5 % du nombre total d'oeufs déposés dans la zone centrale de la côte.

Le relevé par plongée effectué en 1986 était le premier relevé effectué dans la zone centrale de la côte et les résultats ont montré que la répartition des oeufs était semblable à celle d'autres districts. Le frai était limité à la zone intertidale et à la partie supérieure de la zone infratidale (au-dessus d'une limite de 3 m sous le zéro des cartes). Le pourcentage de couverture végétale et le poids des échantillons étaient également similaires à ceux d'autres districts et diminuaient avec la profondeur seulement dans la partie inférieure de la zone infratidale (au-dessous d'une limite de 3 m sous le zéro des cartes). Les couches d'oeufs et leur densité suivaient un profil identique. Toutefois, les pentes des plages étaient beaucoup plus abruptes que celles d'autres aires de ponte étudiées jusqu'à maintenant. De plus, la végétation des frayères différait de celle d'autres districts, et se composait principalement de laminaires, de fucus et d'algues rouges filamenteueses.

## INTRODUCTION

Herring abundance in the Central Coast District (Areas 6 to 9) has recently shown signs of decline (Haist et al. 1986). A first attempt to survey spawn in this District (with divers) was made in 1986 to accurately assess the status of the spawning stocks. Diving surveys of herring spawn were also made for most of the British Columbia coast, except for the Queen Charlotte Islands, to obtain more accurate spawning stock biomass estimates than are possible with the traditional surface surveys. It was also the intention of these surveys to obtain calibration information from simultaneous diving and surface surveys to adjust surface survey estimates for spawns that were not surveyed by divers. The 1986 Central Coast diving survey is the subject of this report.

## MATERIAL AND METHODS

Herring spawns were surveyed independently with traditional surface survey techniques and by SCUBA divers. Surface survey data were collected using a variety of techniques. Visual observations were made from a boat, frequently using a viewing box to enhance the visibility of the bottom. Grapples were used to determine the presence of and obtain samples of spawn. From these observations the length and width of spawn and the layers of eggs were estimated.

The spawn survey by divers used a two-stage sampling design. Transects perpendicular to the shore were the primary sampling unit and 0.50 $m^2$ quadrats along the transect were the secondary sampling unit. Samples consisted of all the rooted or attached vegetation, and the eggs adhering to it, within the quadrat. Layers of eggs, percent of the quadrat covered by vegetation, and the dominant vegetation were estimated by divers for each quadrat. Samples were weighed and weighed subsamples were preserved in Gilson's fluid and egg counts obtained. Eggs on the bottom substrate were calculated from diver estimates of the number of egg layers and percent of bottom covered by vegetation (Haegele et al. 1979) and then added to eggs on vegetation.

Transects were established at approximately equal intervals along the length of the spawn and samples were collected at equal intervals along each transect with the spacing determined by the width of the spawn. The mean egg density and 95% confidence interval were calculated for each spawn and transect means were weighted by transect length (Schweigert et al. 1985). In Area 9 the vegetation zone was generally 5 m or less in width so that it was not possible to establish transects. In fact, the vegetation consisted of a narrow rockweed zone attached to small and large boulders or directly to the steep rock face of the cliffs. Consequently, we obtained a random single quadrat sample at each transect location and collected tansect samples approximately every 1 km along the length of the spawn.

The boundaries of spawns were determined from measurements along transects and the ends of spawns beyond the outer transects were determined on exploratory dives. This information was plotted on maps of marine vegetation at a scale of 1:6000 (e.g., Haegele and Hamey 1980), the boundaries of the spawn contoured, and the area of the spawn measured using a digitizer. When vegetation maps were not available, marine charts were used. Spawn on Macrocystis sp., a giant kelp, was surveyed separately at one location, using the procedure developed by Haegele and Schweigert (1985). Spawner biomass (tonnes) was estimated as the product of spawn area, egg density, and $10^{-8}$, which assumes 200 eggs • gm-1 female weight (Hay 1985) and a 1:1 sex ratio.

The estimated tonnages for each area were based on the diving survey estimate if one was available. Otherwise the tonnage was estimated from the surface survey by adjusting the width to a diving survey estimate and egg density was approximated from a relationship between diving survey egg densities and surface survey estimates of average egg layers as detailed in Schweigert and Stocker (1988).

## RESULTS

In the Central Coast over half of the spawning occurred in Area 7 with the longest single spawn being recorded in Spiller Channel (Table 1, 2; Fig. 1). A small amount of spawn was also surveyed on the giant kelp, Macrocystis sp. (Table 3). It was estimated that 28,767 tonnes of fish were available to spawn in the Central Coast during 1986 (Table 4). Of this total the seine fishery caught 1707 tonnes in Area 7 while the gillnets took 1084 tonnes in Areas 6 and 7. The food and bait fishery removed another 30 tonnes the previous fall and winter in Area 8. The estimates include three late spawns which occurred in June. Other spawn was deposited between March 3 and April 21.

### AREA 6 - KITASU AND WEETEEAM BAYS

The two major spawnings in Area 6 occurred in Kitasu (Fig. 2, 3) and Weeteeam bays. Only the former spawning was covered by the diving survey. The majority of the spawn in Kitasu Bay appeared to be deposited in the Parson's Anchorage and Marvin Island area on Macrocystis sp. with some also being deposited heavily on the stringy red algae in this area. It was estimated that 898 tonnes of fish spawned on understory vegetation, with an additional 88 tonnes spawning on giant kelp (Appendix Table 1, 2). The gillnet fishery took 638 tonnes and an unknown amount was collected as spawn-on-kelp. The total for Kitasu Bay amounts to 1624 tonnes but this figure is probably conservative due to undersampling of Macrocystis because of time constraints and mechanical problems. The egg density was estimated at

256,000 eggs/$m^2$ at 0.60 layers which reflects the patchiness of the vegetation in the area.

The spawns in Weeteeam Bay were surveyed by the guardian for Area 6 who has done the survey for the past several years. The adjusted area was 43.9 ha with an average egg density estimated at 370,000 eggs/$m^2$ for 1623 tonnes of spawners.

In addition the total for the Area includes two late spawns which occurred in June at Hawkesbury and Gil islands estimated at 4541 tonnes. This may be an overestimate because the width adjustment which may not be warranted for these locations. Unfortunately, due to the lateness of this spawn, divers could not visit the spawn site to verify the spawn width.

## AREA 7 - SEAFORTH CHANNEL AND THOMPSON BAY

The major spawnings in this area were all covered by the diving survey (Fig. 4-10), but a number of small scattered late spawnings were sampled only by the surface survey. The majority of the spawn (67%) was contained in three areas: Spiller Channel, Kynumpt Harbour amd vicinity, and Thompson Bay.

Another 14 spawns of 200-300 tonnes each occured in widely scattered areas, primarily Thompson Bay and Kilidit Sound. Egg densities averaged 400,000 eggs/$m^2$ and ranged from 122,000-3,533,000 eggs/$m^2$. The estimate of 1,328,000 eggs/$m^2$ for Bend Point Cove and 3,553,000 eggs/$m^2$ for Princess Alice Island seem unrealistically high. The spawn in these two areas was deposited mostly on an unusual accumulation of drift stringy red algae almost 1 m deep. Although the estimate of 218 tonnes for Bend Point Cove is plausible the estimate of 3475 tonnes for Princess Alice Island is too high. Estimates of egg density based on predictions from the estimates of average egg layers and percent cover or sample weight for Princess Alice Island are for 602,000 and 2,027,000 eggs/$m^2$ equivalent to 589 and 1983 tonnes of spawners. Either of these estimates seem more reasonable than the 3475 tonnes from the egg counts. However, throughout the paper we have based our estimates on the egg counts which means that estimate of total tonnage for the Area and the entire District will be slightly inflated. The seine fishery removed 446 tonnes and the gillnets 1707 tonnes yielding a total prefishery biomass of 16,856 tonnes for all of Area 7.

## AREA 8 - KWAKSHUA AND KWAKUME

Only one small spawning in Pruth Bay was surveyed by the diving team (Fig. 11). A later spawning in Keith Anchorage and spawns at Kwakume were covered by the surface survey. A total of 57.89 ha of spawn were recorded in the Area with an egg density of 329,000 eggs/$m^2$ in Kwakshua and 285,000 eggs/$m^2$ in Keith Anchorage and much heavier deposition of 494,000 eggs/$m^2$ at Kwakume. In addition, a late spawn occured in June in Burke Channel. The

total tonnage including food and bait fisheries was 2874 tonnes for Area 8.

## AREA 9 - RIVERS INLET

An extensive spawning was sampled by the diving survey near the head of Rivers Inlet (Fig 12). The 16.3 km of spawn was deposited on a narrow band of rockweed on the rock faces. The egg deposition averaged 0.66 layers and 493,000 eggs/$m^2$ which translates into 1231 tonnes of spawning fish.

## SAMPLING DESIGN

The spawnings in this assessment region were unusual because they were relatively small and generally much narrower than most areas surveyed to date. The estimates of optimal sampling fractions required to achieve a 25% standard error on the mean estimated egg density were much higher than we have estimated previously for other areas (Table 5). On the other hand, the estimates of the optimal number of transects per km were lower than we have found for other areas and the sampling during this survey usually exceeded the optimal level.

## SPAWN DISTRIBUTION

The distribution of spawn was similar in Areas 6 and 7, and similar in Areas 8 and 9 (Table 6). In the former two areas, most of the spawn was deposited in the intertidal and upper subtidal zone with lesser amounts deeper than 3 m below chart datum. In Areas 8 and 9 virtually all of the spawn occurred shallower than 3 m below chart datum. In fact, in Area 9 all of the spawn was in the intertidal zone because there was no vegetation below the rockweed zone. Egg layers and sample weight also decreased deeper than 3 m below chart datum although there is no clear trend in percent cover (Table 7). The slopes of the spawning areas were similar in Areas 7 and 8 at about 0.30 and more gradual at 0.18 in Area 6 (Table 8). These slopes are steeper than we have found in all other areas of the coast. Similarly, the transects are shorter and begin at greater depths than for most other areas surveyed to date. These results are also reflected in the vegetation substrates utilized for spawn deposition (Table 9). The majority of spawn was deposited on kelp and rockweed in Areas 8 and 9 and kelp and sea grasses in Area 6. Area 7 contained a mixture of these vegetation types plus a majority of spawn on filamentous algae. Although these vegetation types cover a great depth range from the intertidal to more than 6 m below chart datum, most of the eggs were deposited shallower than 3 m below chart datum (Table 6).

## DISCUSSION

Herring spawning stocks in 1986 in the Central Coast were expected to be near 1985 levels (Haist et al. 1986). Since this was the first year of extensive diving surveys in the Central Coast it was difficult to make comparisons of estimates with those from previous years done by surface survey. In addition, a number of problems were noted with the survey methods. The spawns in this area are very different from those in all other areas of the coast. The topography of most of the spawning areas does not lend itself to the two-stage sampling scheme and some form of stratified procedure should be explored. Most of the spawning areas are relatively narrow and drop off to deep depths rapidly. The estimated tonnage for the area is slightly higher than that forecast by the stock assessment models (Haist et al. 1986). This is partly a function of the inclusion of the estimates for the late spawning inlet stocks that are not considered in the assessment of the main migratory bodies of fish. In addition, there is some uncertainty about the accuracy of estimates for two spawns which contained an unusual algal species which appeared to result in unrealistically high estimates of spawning biomass. Overall the survey results indicate that any apparent downturn of stocks in the District may have abated and some improvement may be expected due to an average recruitment in the District comparable to what occured in the southern management regions. This was also the first year of dual survey coverage for calibration of diver and surface survey data and the results should be extremely useful for updating the calibration equations for the escapement model estimates for the Central Coast stock assessment region.

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Table 1. Summary of survey information and estimates of spawner biomass for spawns surveyed by divers in the Central Coast in 1986. Confidence intervals (95%) are in brackets.

| Location | Transect numbers | No. of quadrats | Length (m) | Av. tran. len. (m) | Area (ha) | Av. egg layers | Thousands of eggs per sq. m | Tonnes of spawners |
|---|---|---|---|---|---|---|---|---|
| Area 6 | | | | | | | | |
| Kitasu Bay | 7-16,19,25 | 50 | 14000 | 44 | 35.03 | 0.6 | 256 (0-587) | 898 (0-2056) |
| Area 7 | | | | | | | | |
| Suzette Bay | 5,7,8 | 20 | 590 | 157 | 2.05 | 3.1 | 1062 (0-7225) | 218 (0-1481) |
| Bend Point Cove | 1-3 | 20 | 450 | 82 | 3.46 | 1.3 | 1328 (642-2015) | 460 (222-697) |
| Powell Anchorage | 1-2,5-9 | 34 | 7000 | 35 | 20.10 | 1.2 | 406 (272-540) | 816 (546-1086) |
| Gale Passage | 1-5 | 18 | 5000 | 44 | 22.00 | 1.9 | 389 (0-779) | 857 (0-1713) |
| Spiller Channel | 1-34 | 97 | 34000 | 17 | 56.34 | 1.9 | 586 (434-737) | 3299 (2447-4152) |
| Princess Alice I. | 1-4 | 18 | 900 | 79 | 9.78 | 2.3 | 3553 (3034-4071) | 3475 (2968-3982) |
| Kynumpt Harbour | 1,3,5,7,9,11,13,15, 17,19,20 | 61 | 10000 | 49 | 65.98 | 1.0 | 472 (326-619) | 3117 (2151-4082) |
| Brydon Channel | 1-7,10 | 36 | 3500 | 30 | 14.55 | 1.0 | 328 (229-427) | 477 (333-621) |
| Area 8 | | | | | | | | |
| Pruth Bay | 1-5 | 14 | 2000 | 32 | 8.21 | 0.7 | 329 (6-651) | 270 (5-535) |
| Area 9 | | | | | | | | |
| Rivers Inlet | 1,2,4,8,10,12,14,16, 18,20,22,24,26,28,30 | 15 | 16300 | 15 | 24.75 | 0.7 | 497 (233-762) | 1231 (577-1886) |

Table 2. Estimates of spawner biomass for spawns surveyed only from the surface in the Central Coast in 1986.

| Locality | No. of patches | Length (m) | Av. width (m) | | Area (ha) | Av. egg layers | Thousands of eggs per sq. m | Tonnes |
|---|---|---|---|---|---|---|---|---|
| | | | obs. | adj. | | | | |
| Area 6 | | | | | | | | |
| Hawkesbury Island* | 3 | 14825 | 9 | 51 | 76.08 | 4.5 | 529 | 4028 |
| Gil Island* | 2 | 3890 | 9 | 50 | 19.51 | 2.0 | 263 | 513 |
| Weeteeam Bay | 21 | 5970 | 26 | 74 | 43.91 | 2.8 | 370 | 1623 |
| Area 7 | | | | | | | | |
| E. Higgins Passage | 10 | 3535 | 16 | 64 | 22.64 | 2.0 | 284 | 644 |
| Joanna Rock | 2 | 600 | 3 | 34 | 2.06 | 1.2 | 199 | 41 |
| St. John Harbour | 1 | 600 | 150 | 149 | 8.92 | 1.5 | 234 | 204 |
| Waskesiu Passage | 4 | 1750 | 13 | 60 | 10.53 | 1.4 | 221 | 233 |
| Joassa Channel | 4 | 1375 | 11 | 56 | 7.70 | 0.4 | 122 | 94 |
| Houghton Islands | 7 | 1050 | 11 | 56 | 5.84 | 4.2 | 522 | 305 |
| McNaughton Group | 4 | 710 | 13 | 60 | 4.23 | 4.0 | 501 | 212 |
| Cultus Sound | 1 | 350 | 100 | 128 | 4.47 | 2.5 | 334 | 149 |
| Spitfire Anchorage | 2 | 550 | 10 | 53 | 2.92 | 2.6 | 350 | 102 |
| Area 8 | | | | | | | | |
| Burke Channel* | 3 | 750 | 9 | 49 | 3.68 | 7.4 | 880 | 324 |
| Keith Anchorage | 4 | 1750 | 6 | 45 | 7.83 | 2.0 | 285 | 223 |
| N. of Kwakume Inlet | 4 | 2690 | 3 | 36 | 9.70 | 4.3 | 529 | 513 |
| Kwakume Inlet | 8 | 4090 | 5 | 43 | 17.46 | 3.2 | 415 | 725 |
| Kwakume Point | 3 | 4450 | 3 | 33 | 14.69 | 4.4 | 537 | 789 |

*June spawns

Table 3. Estimates of egg deposition on Macrocystis sp. for Kitasu Bay spawns surveyed in 1986. Confidence intervals (95%) are in brackets.

| | |
|---|---|
| Area surveyed (sq. m) | 150 |
| No. plants sampled | 5 |
| Ave. plant height (m) | 4.8 (3.2 - 6.4) |
| Ave. egg layers | 0.8 (0.1 - 1.6) |
| Area (ha) | 8.13 |
| Density (per ha) of | |
| - plants | 2067 |
| - all fronds | 15133 |
| - mature fronds | 10867 |
| Thousands of eggs per | |
| - plant | 526 (92 - 960) |
| - frond (all) | 72 (40 - 104) |
| - frond (mature) | 120 (13 - 227) |
| Tonnes estimated from | |
| - plants | 88 (15 - 161) |
| - fronds (all) | 88 (49 -127) |
| - fronds (mature) | 106 (11 - 201) |

Table 4. Estimates of total herring spawn and adult herring biomass for the Central Coast in 1986.

| | Area 6 | Area 7 | Area 8 | Area 9 | Central Coast |
|---|---|---|---|---|---|
| Diving survey | | | | | |
| -length (m) | 14000 | 61440 | 2000 | 16300 | 93700 |
| -area (ha) | 35.03 | 194.26 | 8.21 | 24.75 | 262.25 |
| -spawners (t) | 1004 | 12719 | 270 | 1231 | 15224 |
| Surface survey | | | | | |
| -length (m) | 24685 | 10520 | 13730 | 0 | 48935 |
| -area (ha) | 139.50 | 69.31 | 53.36 | 0.00 | 262.17 |
| -spawners (t) | 6164 | 1984 | 2574 | 0 | 10722 |
| Both surveys | | | | | |
| -length (m) | 38685 | 71960 | 15730 | 16300 | 142675 |
| -area (ha) | 174.53 | 263.57 | 61.57 | 24.75 | 524.42 |
| Adult biomass (t) | | | | | |
| -spawners | 7168 | 14703 | 2844 | 1231 | 25946 |
| -catch | 638 | 2153 | 30 | 0 | 2821 |
| -total | 7806 | 16856 | 2874 | 1231 | 28767 |

Table 5. Estimated optimal sampling design to achieve a SE of 25% of the mean (after Schweigert et al. 1985) and achieved sampling density for 1986 diving surveys of herring spawn in the Central Coast.

| Location | Samples per transect | Av. transect length (m) | Achieved sampling fraction | Optimal sampling fraction | Achieved transects per km | Optimal transects per km |
|---|---|---|---|---|---|---|
| Kitasu Bay | 4.4 | 44 | 0.099 | 0.120 | 0.857 | 7.126 |
| Suzette Bay | 6.7 | 157 | 0.042 | 0.029 | 5.085 | 499.157 |
| Bend Point Cove | 6.7 | 82 | 0.081 | 0.117 | 6.667 | 10.996 |
| Powell Anchorage | 4.3 | 35 | 0.121 | 0.418 | 1.143 | 0.714 |
| Gale Passage | 3.6 | 44 | 0.082 | 0.136 | 1.000 | 5.792 |
| Spiller Channel | 3.2 | 17 | 0.190 | 0.422 | 0.882 | 0.313 |
| Princess Alice I. | 4.5 | 79 | 0.057 | 0.147 | 4.444 | 0.731 |
| Kynumpt Harbour | 5.1 | 49 | 0.104 | 0.152 | 1.200 | 0.798 |
| Brydon Channel | 4.5 | 30 | 0.150 | 0.216 | 2.286 | 1.351 |
| Pruth Bay | 2.8 | 32 | 0.088 | 0.073 | 2.500 | 11.447 |

Table 6. Percent distribution of spawn area and eggs for spawns surveyed by divers in the Central Coast in 1986.

| Location | | Depth interval [m above (+) or below (-) chart datum] | | | |
|---|---|---|---|---|---|
| | | Above 0 m | 0 to -3 m | -3 to -6 m | Below -6 m |
| Area 6 | Area | 23.3 | 34.6 | 30.3 | 11.8 |
| | Eggs | 55.3 | 32.7 | 6.5 | 5.5 |
| Area 7 | Area | 31.2 | 40.1 | 16.4 | 12.3 |
| | Eggs | 37.1 | 50.3 | 8.4 | 4.2 |
| Area 8 | Area | 86.2 | 13.8 | 0.0 | 0.0 |
| | Eggs | 65.9 | 34.1 | 0.0 | 0.0 |
| Area 9 | Area | 91.8 | 3.9 | 0.0 | 0.0 |
| | Eggs | 93.8 | 3.6 | 0.0 | 0.0 |
| Central Coast | Area | 37.6 | 35.1 | 16.5 | 10.8 |
| | Eggs | 44.4 | 44.3 | 7.5 | 3.8 |

Table 7. Wilcoxon mean and estimated 95% confidence interval for % cover of vegetation, egg layers, sample weight, and egg density for spawn on bottom vegetation and substrate sampled by divers in the Central Coast in 1986. Samples with less than 0.1 egg layers were excluded.

| Location | | Depth interval [m above (+) or below (-) chart datum] | | | |
|---|---|---|---|---|---|
| | | Above 0 m | 0 to -3 m | -3 to -6 m | Below -6 m |
| Area 6 | No. of samples | 10 | 14 | 10 | 2 |
| | % cover | 80 (48-98) | 70 (53-83) | 68 (40-100) | - |
| | egg layers | 1.1 (0.6-1.5) | 0.6 (0.4-1.0) | 0.3 (0.2-0.7) | - |
| | sample weight (g) | 2281 (1028-4130) | 1684 (982-2847) | 1124 (567-1661) | - |
| | eggs/sq. m (1000's) | 633 (181-1172) | 286 (135-563) | 81 (16-210) | - |
| Area 7 | No. of samples | 98 | 108 | 37 | 16 |
| | % cover | 53 (48-60) | 64 (60-75) | 65 (53-75) | 46 (28-63) |
| | egg layers | 1.8 (1.5-2.1) | 1.5 (1.3-1.8) | 0.9 (0.6-1.3) | 1.6 (0.8-2.3) |
| | sample weight (g) | 1978 (1524-2413) | 2494 (1845-3467) | 1290 (936-1835) | 1368 (879-1998) |
| | eggs/sq. m (1000's) | 689 (488-979) | 715 (503-1160) | 299 (171-467) | 231 (96-469) |
| Area 8 | No. of samples | 8 | 5 | 0 | 0 |
| | % cover | 73 (50-90) | 73 (50-100) | - | - |
| | egg layers | 0.8 (0.2-1.7) | 1.2 (0.1-4.0) | - | - |
| | sample weight (g) | 1269 (488-3784) | 2038 (758-8328) | - | - |
| | eggs/sq. m (1000's) | 264 (49-984) | 760 (57-3458) | - | - |

Table 7 (cont'd)

| Location | | Depth interval [m above (+) or below (-) chart datum] | | | |
|---|---|---|---|---|---|
| | | Above 0 m | 0 to -3 m | -3 to -6 m | Below -6 m |
| Area 9 | No. of samples | 15 | 0 | 2 | 0 |
| | % cover | 78 (63-88) | - | - | - |
| | egg layers | 0.6 (0.5-0.9) | - | - | - |
| | sample weight (g) | 4350 (2887-5744) | - | - | - |
| | eggs/sq. m (1000's) | 493 (225-835) | - | - | - |
| Central coast | No. of samples | 131 | 127 | 49 | 18 |
| | % cover | 58 (53-65) | 65 (60-75) | 65 (55-75) | 50 (33-65) |
| | egg layers | 1.5 (1.3-1.8) | 1.4 (1.1-1.6) | 0.7 (0.5-1.0) | 1.6 (0.6-2.0) |
| | sample weight (g) | 2209 (1813-2660) | 2301 (1812-3125) | 1236 (958-1594) | 1308 (862-1912) |
| | eggs/sq. m (1000's) | 610 (463-821) | 633 (457-911) | 254 (149-383) | 227 (98-415) |

Table 8. Description of transect length and beach slope, and outer (OES) and inner edge (IES) of spawn in m above (+) or below (-) chart datum for spawns surveyed by divers in the Central Coast in 1986.

| Location | | Length (m) | Slope | OES | IES |
|---|---|---|---|---|---|
| Area 6 | No. of tran. | 14 | 12 | 12 | 12 |
| | Average | 39 | 0.184 | -4.6 | +0.1 |
| | S. D. | 46 | 0.167 | 3.2 | 1.7 |
| | 95% C. I. | 13 to 65 | 0.077 to 0.290 | -6.7 to -2.6 | -1.0 to +1.3 |
| | Minimum | 5 | 0.024 | 0.0 | -2.6 |
| | Maximum | 167 | 0.624 | -11.3 | +3.2 |
| Area 7 | No. of tran. | 76 | 72 | 72 | 72 |
| | Average | 38 | 0.289 | -4.2 | +1.8 |
| | S. D. | 45 | 0.244 | 3.5 | 1.7 |
| | 95% C. I. | 28 to 48 | 0.231 to 0.346 | -5.0 to -3.3 | +1.4 to +2.2 |
| | Minimum | 3 | 0.014 | -16.2 | -4.3 |
| | Maximum | 303 | 1.150 | +1.6 | +3.5 |
| Area 8 | No. of tran. | 5 | 5 | 5 | 5 |
| | Average | 32 | 0.305 | -1.0 | +1.4 |
| | S. D. | 52 | 0.331 | 1.5 | 1.0 |
| | 95% C. I. | 0 to 96 | 0.000 to 0.717 | -2.9 to +0.8 | +0.2 to +2.6 |
| | Minimum | 6 | 0.007 | -2.8 | -0.1 |
| | Maximum | 124 | 0.755 | +1.0 | +2.4 |
| Area 9 | No. of tran. | 15 | 2 | 2 | 2 |
| | Average | 15 | - | - | - |
| | S. D. | 23 | - | - | - |
| | 95% C. I. | 3 to 28 | - | - | - |
| | Minimum | 2 | - | - | - |
| | Maximum | 78 | - | - | - |

Table 8 (cont'd)

| Location | | Length (m) | Slope | OES | IES |
|---|---|---|---|---|---|
| Central Coast | No. of tran. | 110 | 91 | 91 | 91 |
| | Average | 35 | 0.284 | -4.1 | +1.6 |
| | S. D. | 43 | 0.245 | 3.4 | 1.7 |
| | 95% C. I. | 27 to 43 | 0.233 to 0.335 | -4.8 to -3.4 | +1.2 to +1.9 |
| | Minimum | 2 | 0.007 | -16.2 | -4.3 |
| | Maximum | 303 | 1.150 | +1.6 | +3.5 |

Table 9. Number of samples by dominant vegetation on which herring spawn was deposited for spawns surveyed by divers in the Central Coast in 1986.

| Location | | Depth interval [m above (+) or below (-) chart datum] | | | | |
|---|---|---|---|---|---|---|
| | | Above 0 m | 0 to -3 m | -3 to -6 m | Below -6 m | All depths |
| Area 6 | Sea grasses | 6 | 7 | 2 | 0 | 15 |
| | Rockweed | 1 | 0 | 0 | 0 | 1 |
| | Kelp | 1 | 6 | 8 | 2 | 17 |
| | Foliose algae | 0 | 0 | 0 | 0 | 0 |
| | Filamentous algae | 2 | 1 | 0 | 0 | 3 |
| Area 7 | Sea grasses | 15 | 24 | 2 | 0 | 41 |
| | Rockweed | 42 | 4 | 0 | 0 | 46 |
| | Kelp | 5 | 33 | 30 | 15 | 83 |
| | Foliose algae | 2 | 3 | 0 | 0 | 5 |
| | Filamentous algae | 34 | 44 | 5 | 1 | 84 |
| Area 8 | Sea grasses | 6 | 1 | 0 | 0 | 7 |
| | Rockweed | 0 | 0 | 0 | 0 | 0 |
| | Kelp | 0 | 2 | 0 | 0 | 2 |
| | Foliose algae | 0 | 0 | 0 | 0 | 0 |
| | Filamentous algae | 2 | 2 | 0 | 0 | 4 |
| Area 9 | Sea grasses | 0 | 0 | 0 | 0 | 0 |
| | Rockweed | 15 | 0 | 0 | 0 | 15 |
| | Kelp | 0 | 0 | 2 | 0 | 2 |
| | Foliose algae | 0 | 0 | 0 | 0 | 0 |
| | Filamentous algae | 0 | 0 | 0 | 0 | 0 |
| Central Coast | Sea grasses | 27 | 32 | 4 | 0 | 63 |
| | Rockweed | 58 | 4 | 0 | 0 | 62 |
| | Kelp | 6 | 41 | 40 | 17 | 104 |
| | Foliose algae | 2 | 3 | 0 | 0 | 5 |
| | Filamentous algae | 38 | 47 | 5 | 1 | 91 |

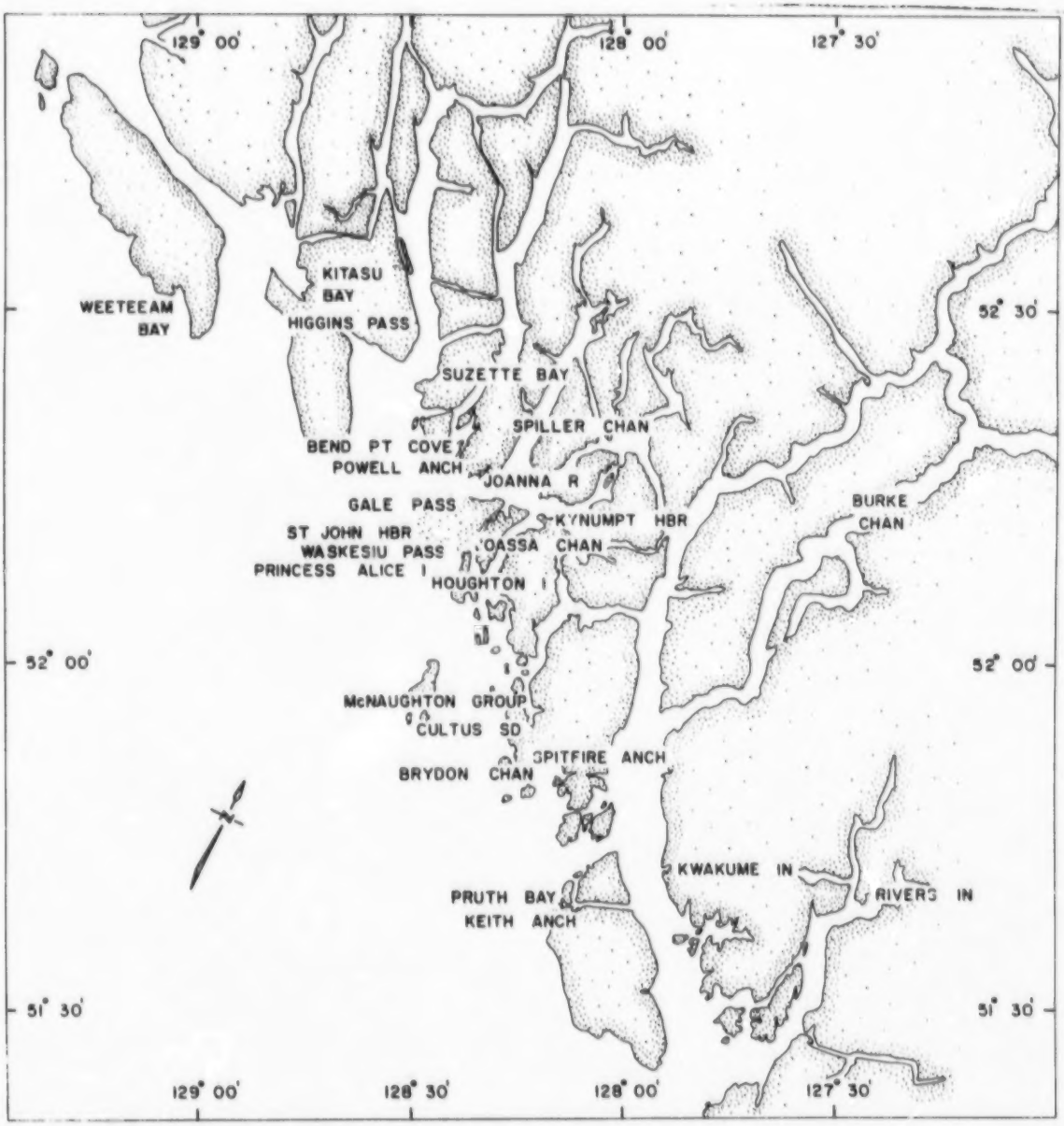


Fig. 1. Chart showing the locations of the areas surveyed in the Central coast during 1986 by divers.

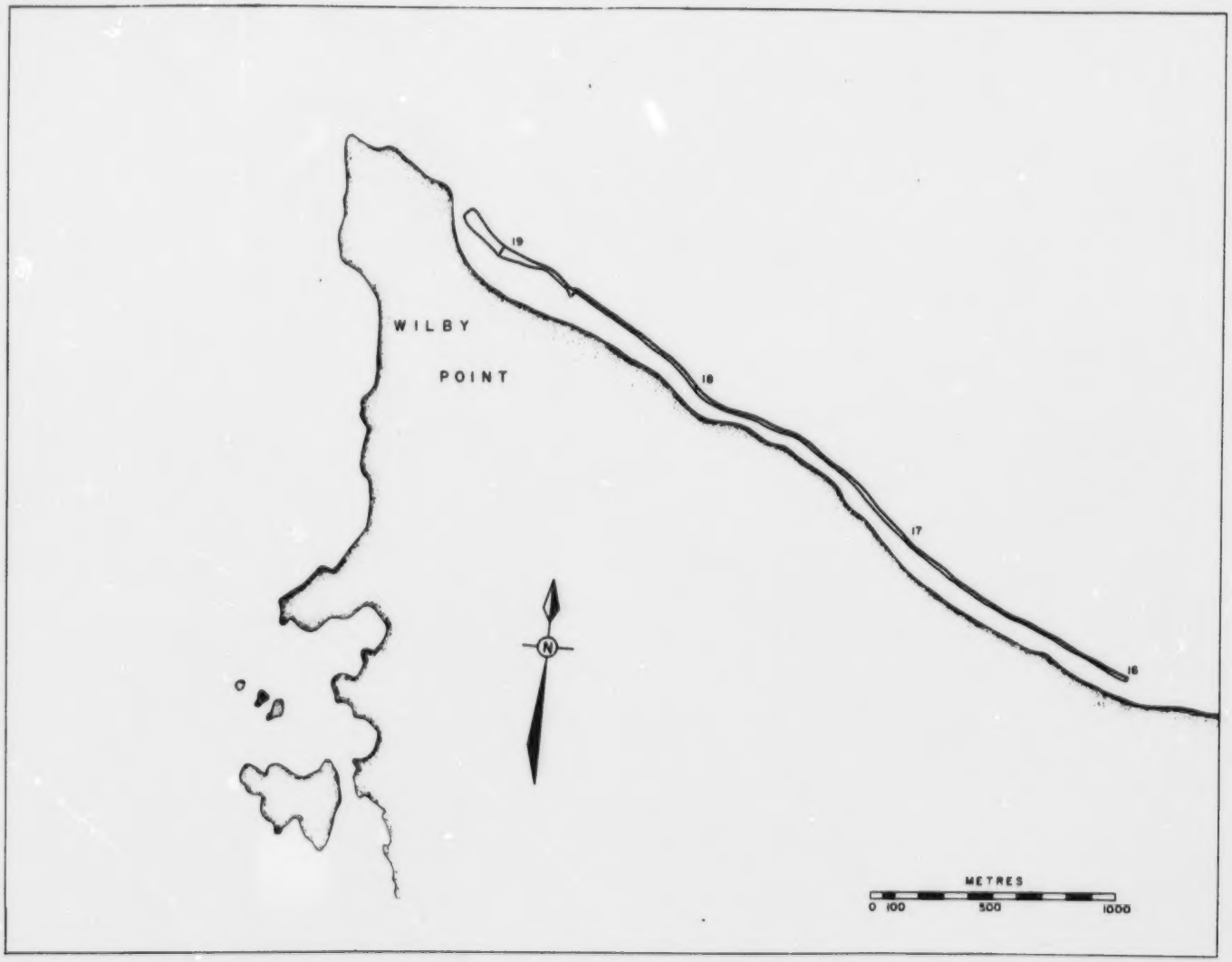


Fig. 2. Herring spawn at Wilby Point in Kitasu Bay in Area 6, surveyed by divers in 1986, with transect locations shown.

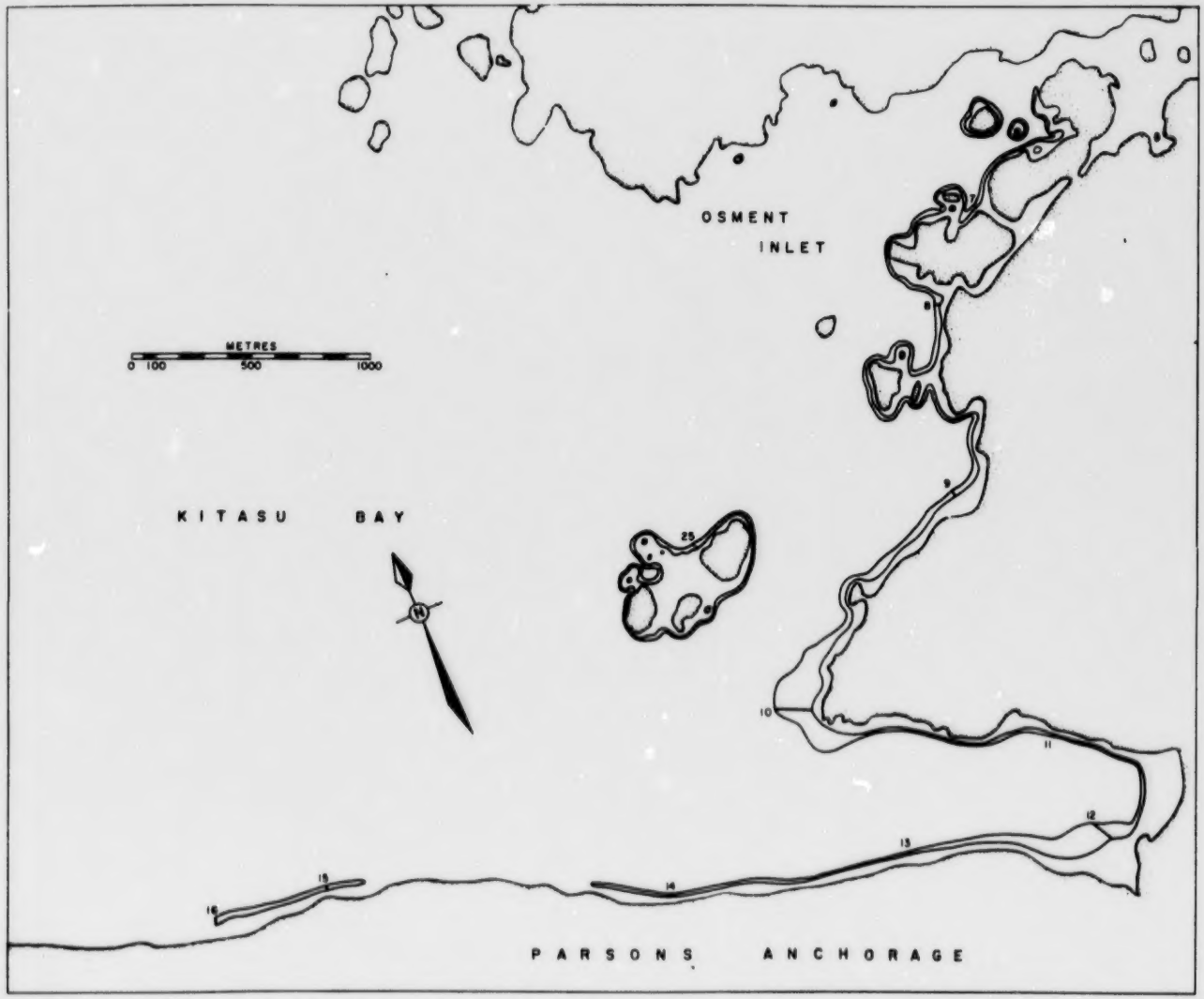


Fig. 3. Herring spawn at the head of Kitasu Bay in Area 6, surveyed by divers in 1986, with transect locations shown.

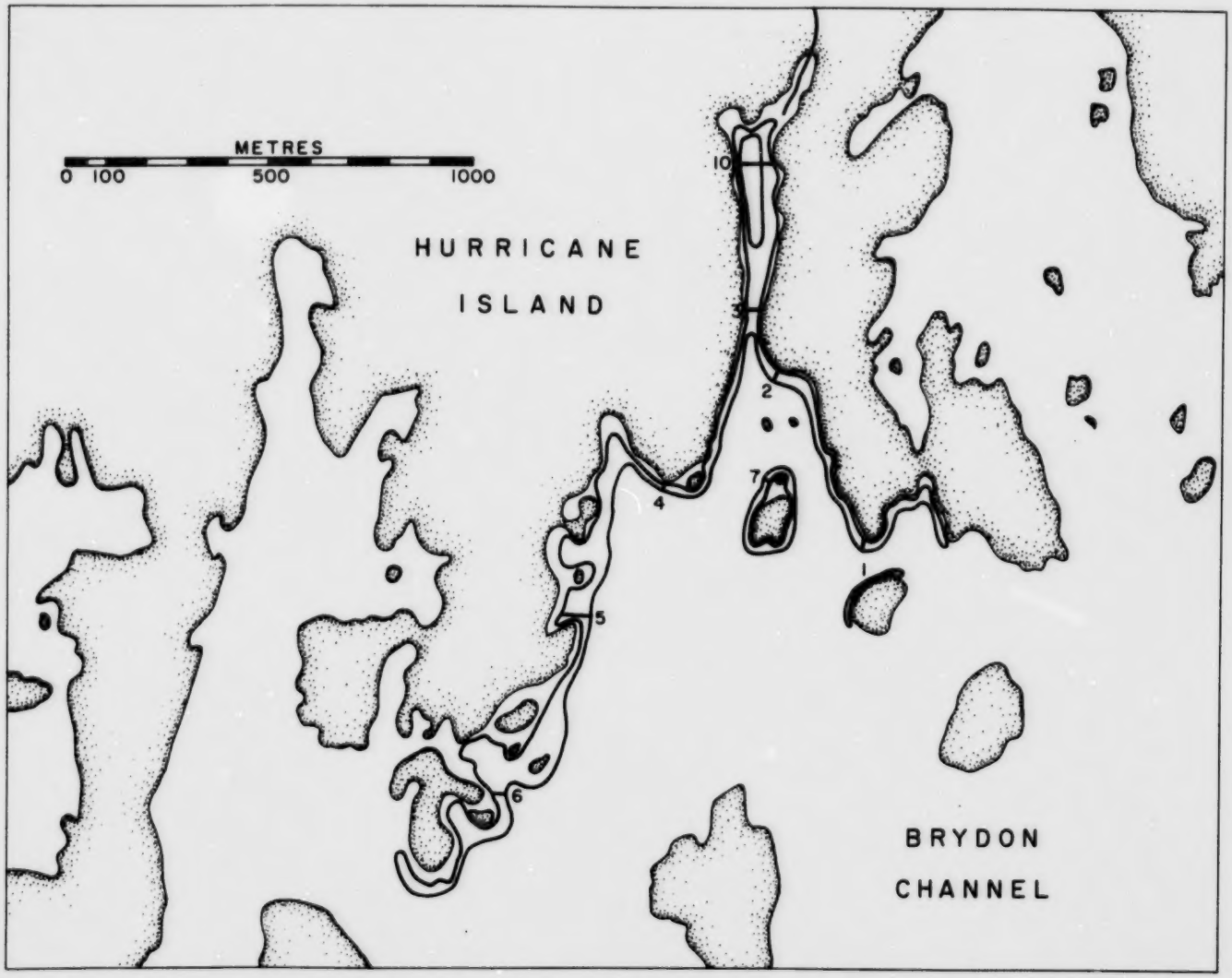


Fig. 4. Herring spawn in Brydon Channel in Area 7, surveyed by divers in 1986, with transect locations shown.

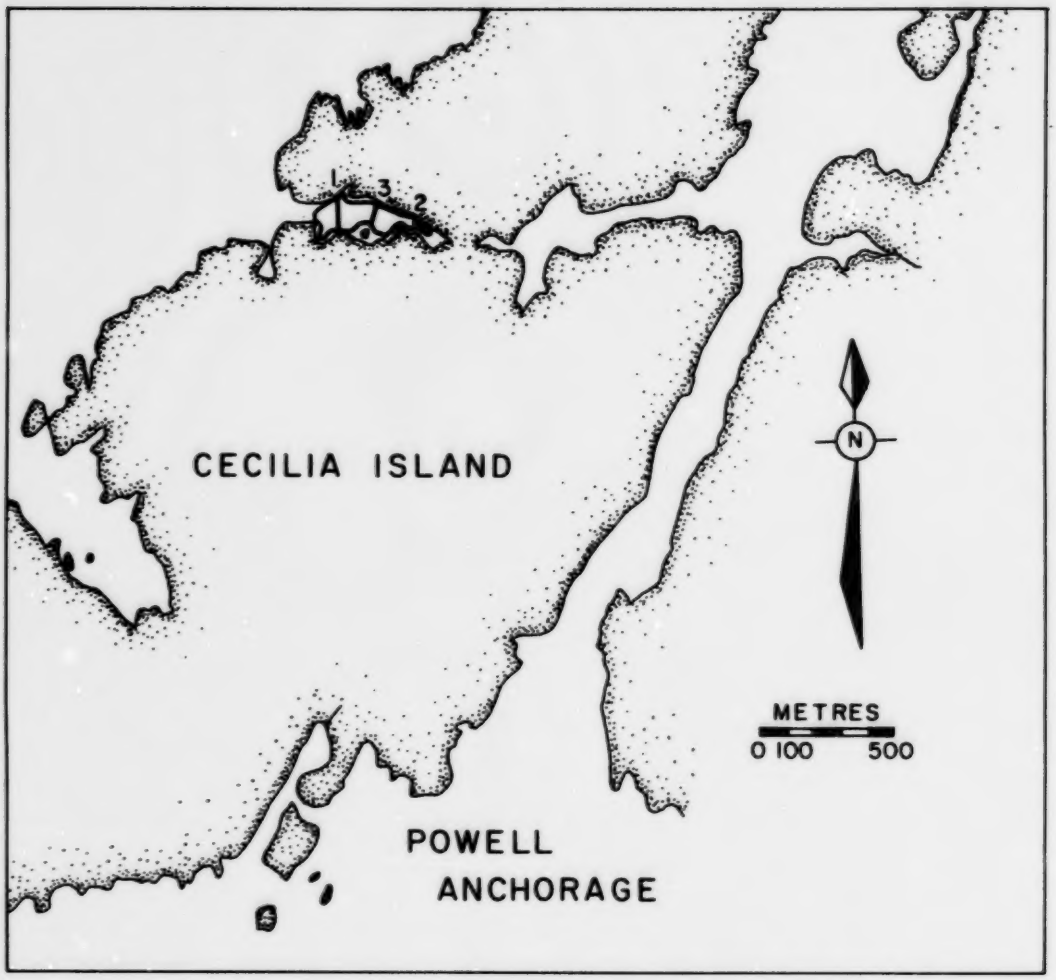


Fig. 5. Herring spawn in Bend Point Cove on Cecilia Island in Area 7, surveyed by divers in 1986, with transect locations shown.

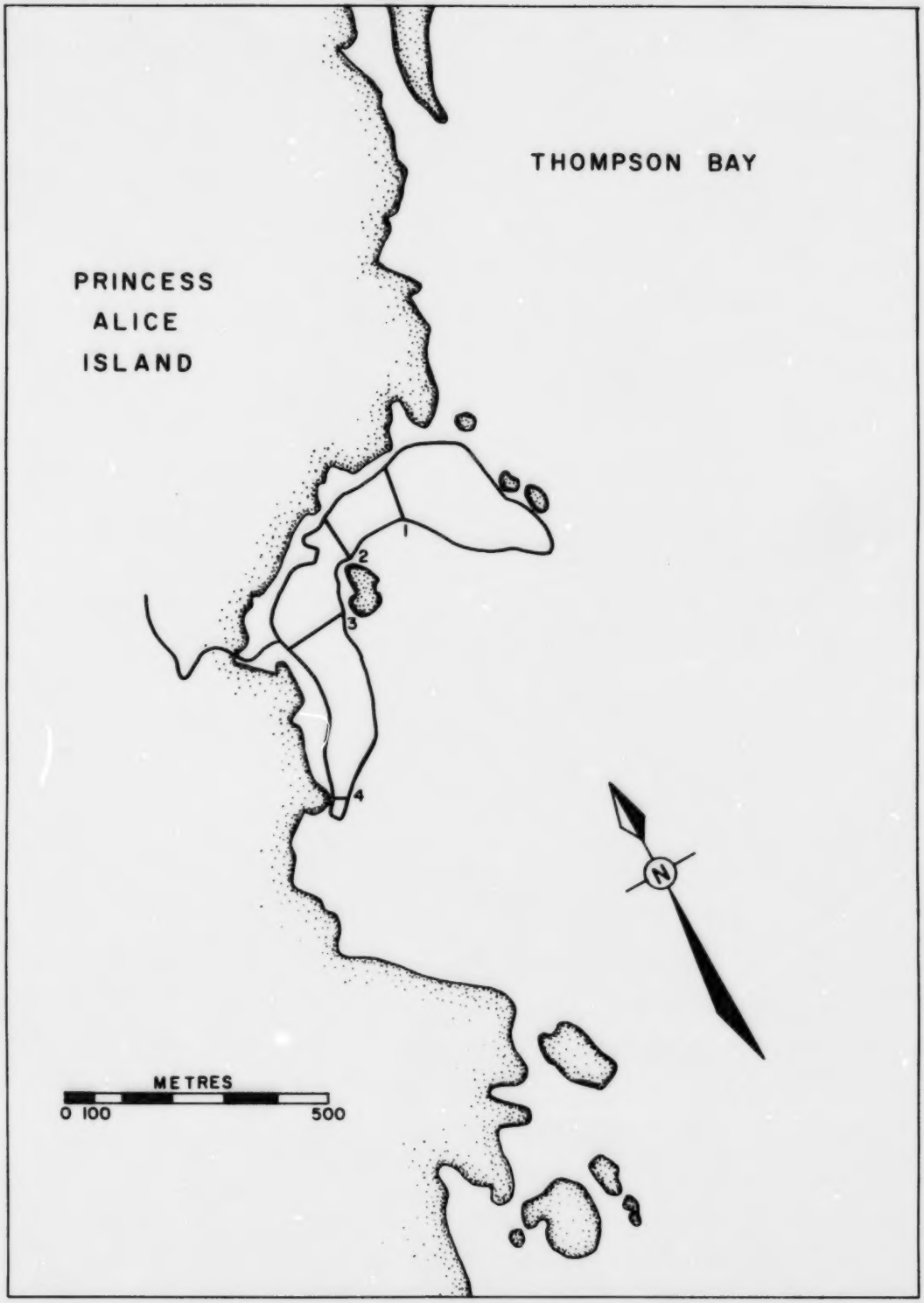


Fig. 6. Herring spawn near Princess Alice Island in Thompson Bay in Area 7, surveyed by divers in 1986, with transect locations shown.

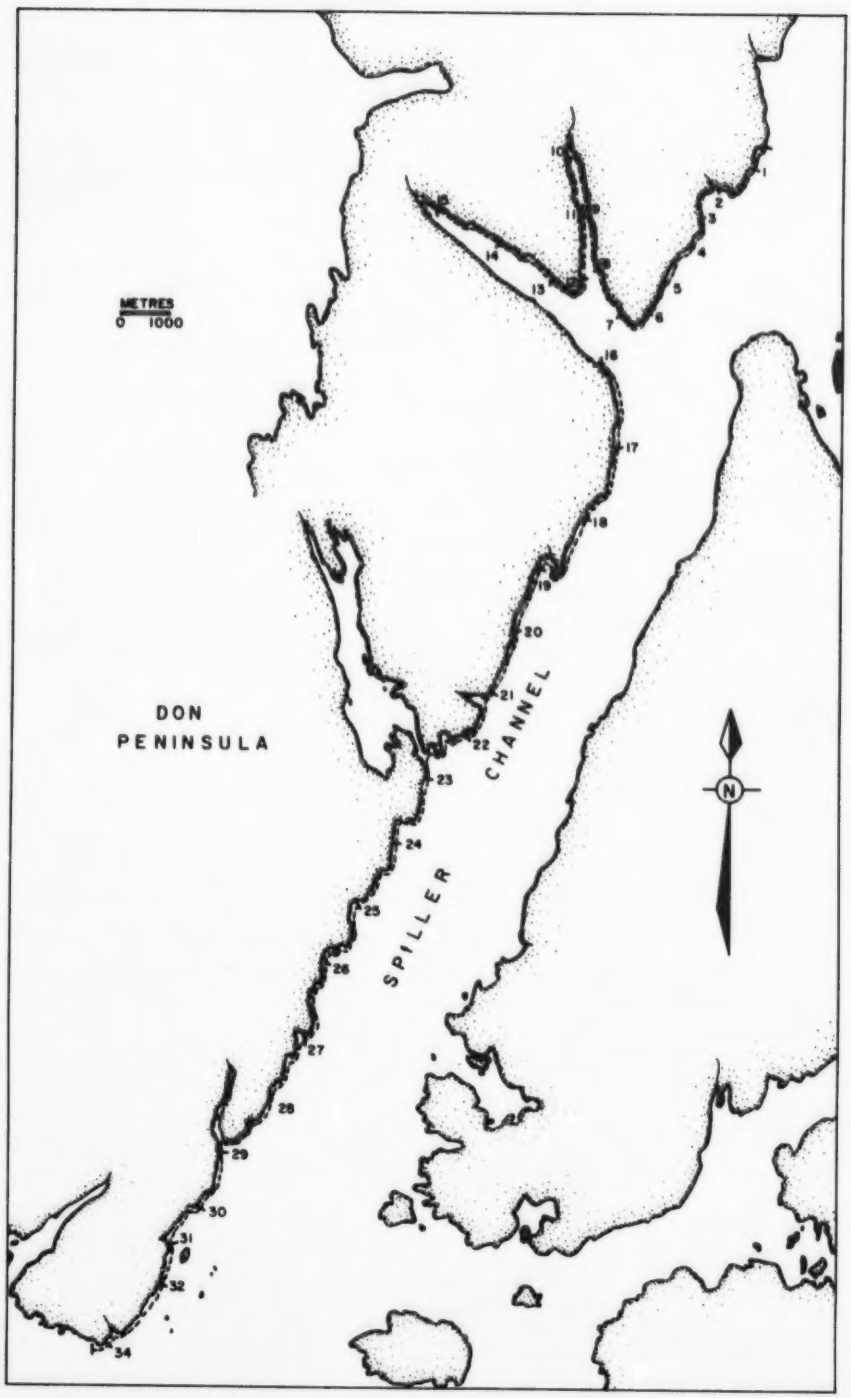


Fig. 7. Herring spawn in Spiller Channel in Area 7, surveyed by divers in 1986, with transect locations shown.

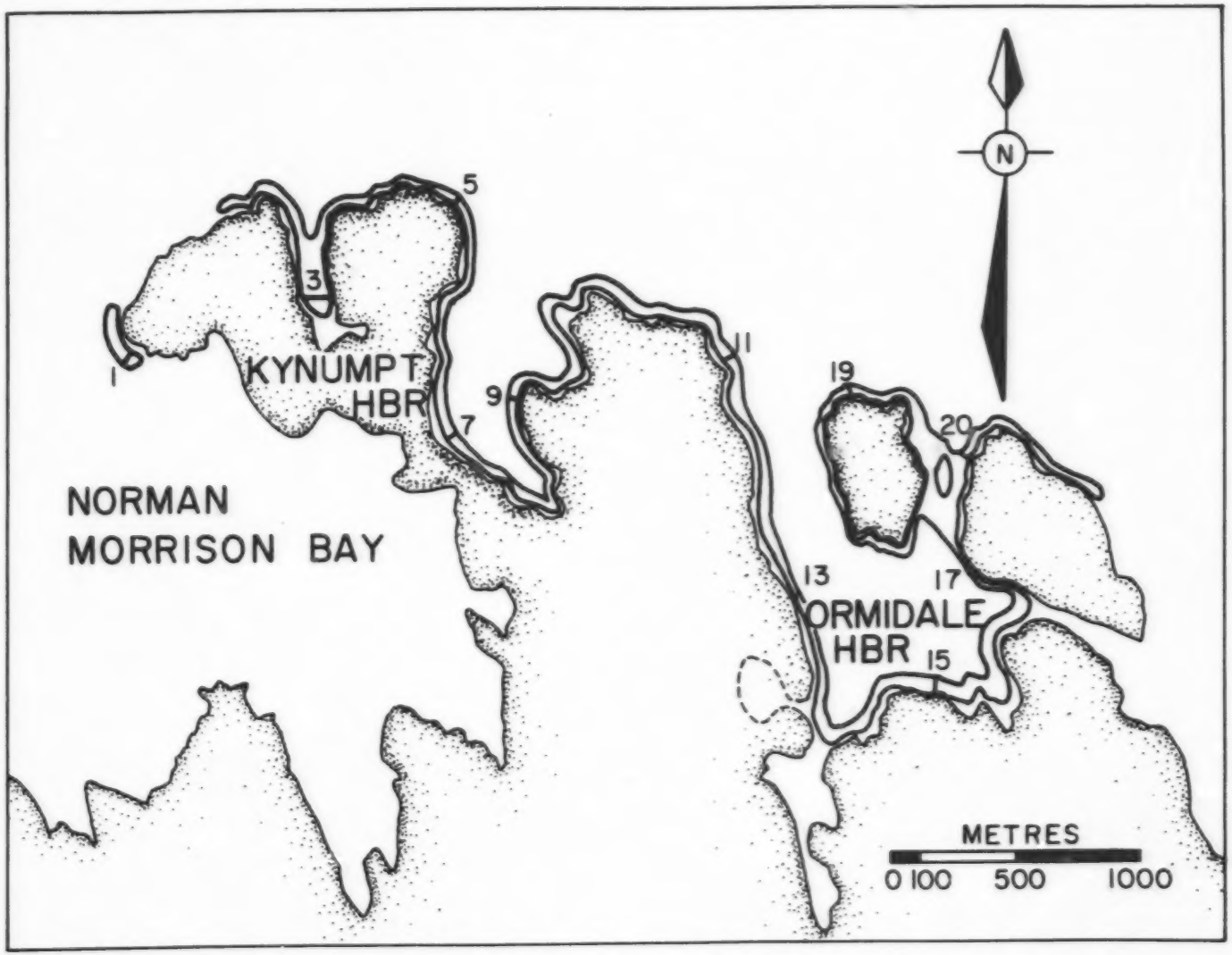


Fig. 8. Herring spawn in Kynumpt and Ormidale Harbours in Area 7, surveyed by divers in 1986, with transect locations shown.

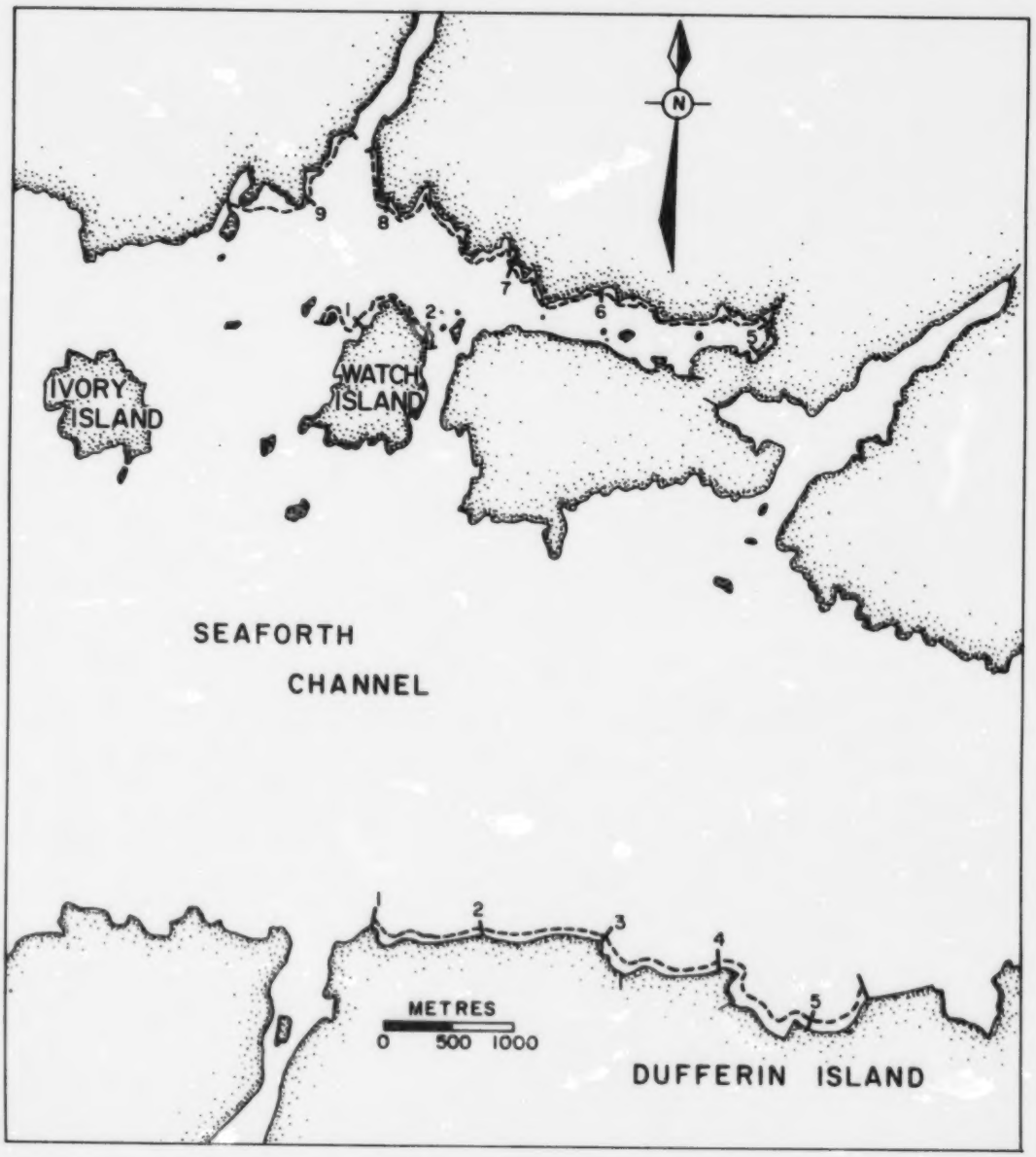


Fig. 9. Herring spawn in Powell Anchorage and Watch Island and in Seaforth Channel near Gale Passage in Area 7, surveyed by divers in 1986, with transect locations shown.

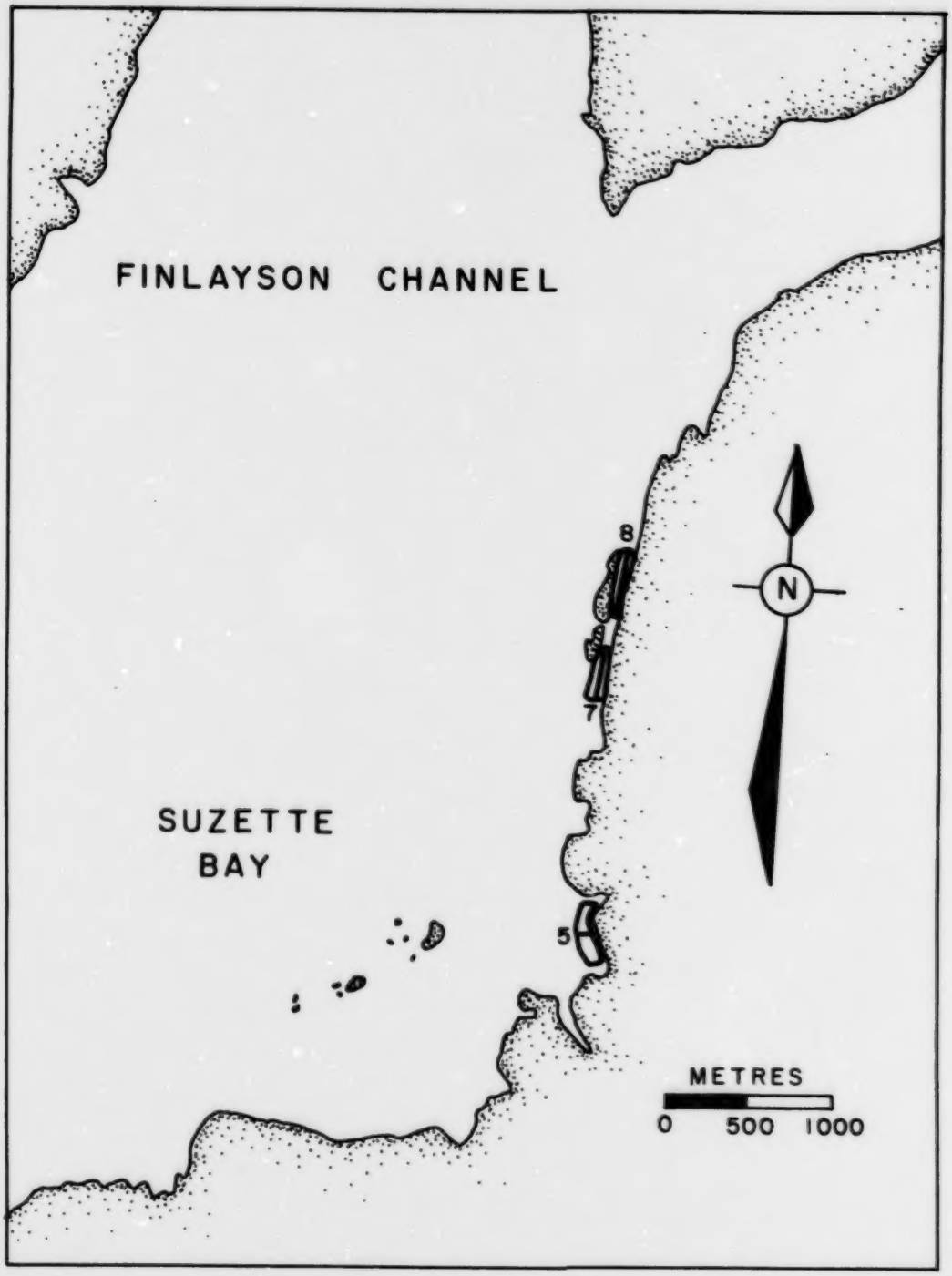


Fig. 10. Herring spawn in Suzette Bay in Area 7, surveyed by divers in 1986, with transect locations shown.

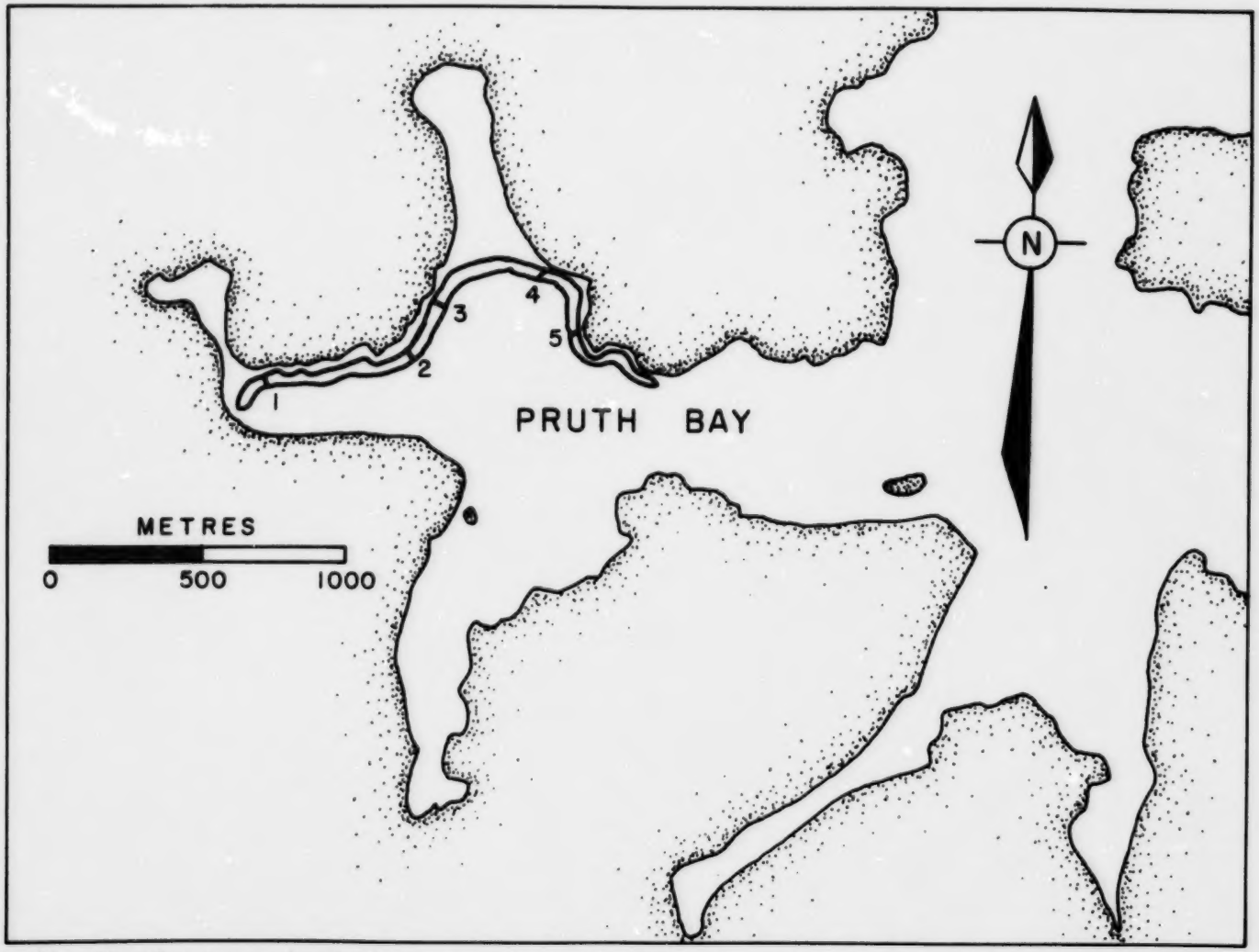


Fig. 11. Herring spawn in Pruth Bay at the head of Kwakshua Channel in Area 8, surveyed by divers in 1986, with transect locations shown.

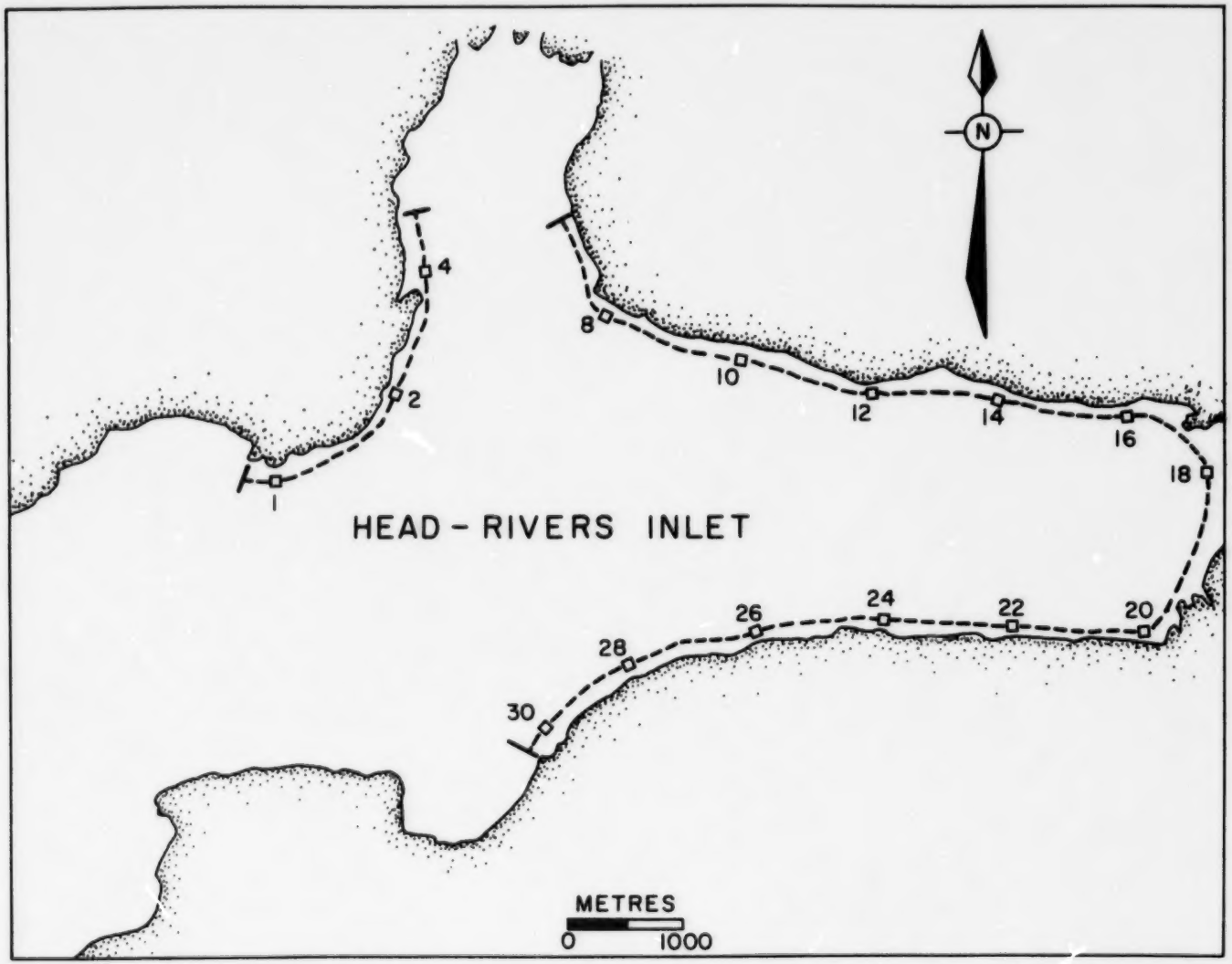


Fig. 12. Herring spawn at head of River's Inlet in Area 9, surveyed by divers in 1986, with transect locations shown.

Appendix Table 1. Macrocystis sp. transect information for spawns surveyed by divers in Kitasu Bay in 1986. (MP = mature plants, IP = immature plants, MF = mature fronds, IF = immature fronds, AF = all fronds.)

| Transect no. | Transect length (m) | Surveyed area (sq. m) | No. of plants | | No. of MP fronds | | | No. of IP-IF |
|---|---|---|---|---|---|---|---|---|
| | | | MP | IP | MF | IF | AF | |
| 10 | 5 | 10 | 1 | 0 | 12 | 2 | 14 | 0 |
| 13 | 20 | 40 | 15 | 0 | 43 | 40 | 83 | 0 |
| 14 | 30 | 60 | 7 | 0 | 33 | 7 | 40 | 0 |
| 15 | 10 | 20 | 2 | 0 | 47 | 11 | 58 | 0 |
| 16 | 5 | 10 | 5 | 1 | 21 | 4 | 25 | 2 |
| 17 | 5 | 10 | 1 | 0 | 7 | 0 | 7 | 0 |
| Total | | 150 | 31 | 1 | 163 | 64 | 227 | 2 |

Appendix Table 2. Results for harvested Macrocystis sp. plants collected in Kitasu Bay in 1986. (MP = mature plant, MF = mature fronds, AF = all fronds.)

| Transect no. | Height (m) | Egg layers | No. fronds | | Thousands of eggs per | | | Plant weight (g) |
|---|---|---|---|---|---|---|---|---|
| | | | MF | AF | MP | MF | AF | |
| 10 | 4 | 1.0 | 17 | 25 | 939 | 55 | 38 | 6630 |
| 13 | 3 | 0.5 | 1 | 3 | 271 | 271 | 90 | 1102 |
| 14 | 5 | 1.8 | 1 | 1 | 99 | 99 | 99 | 1141 |
| 15 | 6 | 0.6 | 8 | 10 | 791 | 99 | 79 | 3034 |
| 16 | 6 | 0.2 | 7 | 10 | 532 | 76 | 53 | 7110 |